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American Quarterly of Roentgenology

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VOL. V. SEPTEMBER, 1913 No. 1

AN ANALYSIS OF THE VARIOUS FORMS OF ENERGY SUPPLY FOR THE GENERATION OF X-RAYS.

BY S. CABOT, BROOKLINE, MASS.

During the past three years I have been making quantitative measurements of electrical energy supplied by apparatus for producing X-Rays and analyzing the qualities of the ray produced, in the endeavor to determine what form of electrical energy supply gives the best results in X-Ray production for the various uses which are made of it by the Radiologists. Some of the results of this work seem to offer an explanation of the reason why different forms of apparatus give different results with the same tube and are more suitable for one purpose than another.

In the following paper I have somewhat dogmatically asserted certain theories which I today believe correct, in order to save the time of the meeting in explaining how I arrived at them. These theories are mainly those of others restated in a manner more intelligible to me and I hope more intelligible to you. Discussion of these theories later on supplemented by further research work to prove their correctness or fallacy in doubtful cases, it is hoped may benefit the art of Radiology in reducing it to a more exact science.

In order to understand why different forms of energy supply give different results we must bear clearly in mind the factors which govern the quantity and quality of the ray.

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In considering X light it is necessary to keep these two factors separate. Perhaps if we consider the following mechanical analogy, the reason for this will be more apparent. Let us suppose we have a gun capable of firing an enormous number of bullets in a short time and that both the number of bullets per second and the velocity with which they leave the gun are separately under control. Suppose also a thick wall composed mostly of butter in which there are blow holes of air and water, chunks of wood, etc. We fire our gun through this wall at a lead screen with the purpose of producing a bas relief of the inner contents of the wall on the lead screen. If we use too low a velocity only bullets which pass mostly through the blow holes of air arrive at the screen with sufficient force to mark it. If we use too high velocity the screen will be marked uniformly by all the bullets without leaving enough indication of what they passed through. The velocity giving the best bas relief will be that which causes the bullets which passed through the chunks of wood to hit the screen with just enough force barely to dent it, while those passing through blow holes of air, by their repeated action in the same place mark the screen deeply. A second and totally independent factor in making our bas relief must be considered and that is to use the right number of bullets to get a deep bas relief without eating holes through the lead screen. Now in the X-ray tube if we multiply the milliampere seconds by a certain definite number we get the exact number of bullets fired to make the exposure. The voltage across the terminals of the tube at the instant any bullet is fired determines its velocity. Each milliampere passing through the tube causes a certain definite number of corpuscles per second to impact on the target. Each impact causes a pulse in the luminiferous ether. The quality of each pulse depends on the voltage maintained across the tube terminals at the instant of impact.

With a given voltage maintained on the tube terminals the rate per second at which corpuscles must impact on the target to sustain this voltage varies with the condition of tube vacuum being great with low vacuums and correspondingly small with high vacuums. With a given condition of vacuum on the other hand this rate of impact will vary more or less proportionately with voltage maintained on terminals dependent on what may be called the resistance characteristics of the tube. If we bear these facts sufficiently clearly in mind the reasons why different forms of energy supply give different results on the same tube become clear.

Perhaps the best measure of quality from the Radiologist's standpoint would be that thickness of tissue which absorbs half of the energy of the ray and allows the remainder to pass through, since by using this system of measurement we are enabled to calculate the distribution of the energy absorption throughout all portions of the tissue penetrated by X light.

The measure of quality most commonly in use today is the thickness of aluminum in millimeters which absorbs the same proportion of energy as a sheet of silver .11 millimeters thick. This is known as the Benoist penetration gauge.

In order to study the distribution of energy absorption through tissue penetrated by X light, an apparatus which had the ability to maintain an unfluctuating voltage on the tube terminals was constructed. This provided means of producing X light very nearly a single degree of quality or penetration instead of a mixture of penetrations unsusceptible of analysis such as must occur if the voltage on the tube terminals is allowed to fluctuate while the current is flowing through it as in the case of the coil or transformer.

Quantitative measurements have been made at the Mass. General Hospital during the past two years with the cooperation of Dr. Walter J. Dodd.

Results of these measurements which may be of interest are as follows:

I. The truth of Sir. J. J. Thompson's law governing the dissipation of X light as it penetrates an absorbing medium was checked within the limits of observation. This law may be stated as follows: Each unit of thickness penetrated absorbs a fixed percentage of the energy transmitted to it and this percentage is dependent upon the penetration of the ray and the nature of the absorbing medium.

II. The thickness of dissipating medium penetrated which absorbed a fixed percentage of energy of X light, was found to be directly proportional to the voltage maintained on the tube terminals.

III. It was discovered that using tungsten or platinum targets the voltage maintained on the tube terminals might be read from the Benoist gauge. Thus, 3 Benoist was produced by 30,000 volts; 5 Benoist was 50,000, etc.

IV. The absorption of energy at the various degrees of penetration in common use as it penetrated tissue was measured

and a set of curves prepared showing graphically the distribution of energy absorption. These are herewith appended. It is hoped that by means of these curves we may attain a more accurate knowledge in therapeutic work of the dosage reaching a diseased part located below the surface of the skin. They may also help as a guide in Radiography and Radioscopy in giving the operator an idea as to the amount of X light available, after penetrating tissue, for affecting the screen or plate at the different readings of the Benoist gauge.

They may also be a guide to the amount X light absorbed in Radiographic or Fluoroscopic examination so that the operator may at once calculate the additional dosage to be given in case therapeutic treatment of non superficial diseased tissue is demanded.

The data from which these curves were attained were arrived at by watching areas on a photographic plate which were equally darkened by exposure. This method is not susceptible of great accuracy and there is a possible error of about 20%. It is proposed to repeat the observations using some form of indicating instrument like Villards Electrometer.

In the meantime these curves are offered as a guide in want of a better.

Let us now turn to a consideration of the resistance characteristics of the X-ray tube for this is what determines the voltage across its terminals when a given current is flowing through them and is thus the sole factor governing the quality of the ray with a given current. On the other hand with a given voltage maintained on the tube terminals, it is the sole factor or rate at which rays of this quality are emitted.

When a new tube in good condition is received from the maker it will commence to pass current of a few milliamperes when the terminal pressure is about 20,000 volts. As the current through the tube is increased this terminal pressure rises reaching about 90,000 volts at 200 milliamperes.

As the tube gets more seasoned the lowest voltage at which it will light increases and the rise in terminal pressure as current is increased becomes less marked.

Finally it reaches the "crank" stage requiring about 100,000 volts to cause it to pass current, but when current once starts the resistance of the tube immediately drops to a low value causing a rush of current from the apparatus of such value that

the internal resistance of the apparatus consumes most of the available voltage leaving very little on the tube terminals and consequently there may be no rays of sufficient penetration emitted.

When a tube is actuated by high potential rectified A. C., as in the case of transformers, it emits rays of all degrees of penetration. However the largest current value flows through the tube at the instant that voltage is greatest and it is near this instant that the bulk of action is done on the plate, so that the result and quality indicated by the penetration gauge is not greatly less than that which would be produced by a maintained voltage on the tube terminals of this same magnitude.

The relative proportion in which rays of the different penetrations are mixed is determined by the resistance characteristics of the tube which change from day to day. This causes some difficulty in obtaining uniform results day after day in radiographic work.

Current is flowing through the tube about two-thirds of the total time and the maximum value is about 2 to 3 times that indicated by milliameter. This latter, however, is a correct gauge of the number of corpuscles impacting as it correctly integrates the variations.

In the case of the induction coil energizing a tube, we also have a mixture of penetrations. This supplies energy to the tube in pulses of very great intensity. These pulses are separated from each other by relatively long intervals of time. The maximum current value in the tube is anywhere from 10 to 50 times that shown on the milliameter. For this reason the same tube banks up a much greater voltage than it does on the transformer with a given tube in a given state of vacuum. The resultant penetration of the rays produced with a given number of milliamperes will, therefore, always be considerably greater. This method of energizing the tube by intermittent pulses of great current amplitude, separated by relatively long intervals of time, is very hard on platinum targets. If there is enough heat produced to melt a spot on the target, the mechanical force exerted by these heavy sudden rushes of current often becomes sufficient to displace the molten platinum and a hole is drilled in the target. The transformer having roughly about a fifth of the maximum current amplitude of the coil, for a given number of milliamperes registered, is correspondingly easier on targets.

If we work with an unfluctuating voltage on the tube terminals, the registered current is the maximum current amplitude and is therefore correspondingly easier on targets. The advent of tungsten targets, which are not readily melted, has done much to lessen the annoyance caused by target drilling.

Results of the analytical work at the Mass. General Hospital during the past two years indicate the following essentials for best work in Radiography, Radisocopy and Radiotherapy.

Radiography:

The apparatus should have the ability to maintain voltages of from 30,000 to 80,000 as desired on the terminals of the tube while current is flowing. It should have the ability to dissipate about 10 K. W. of energy in the tube if the fastest work is desired. Greater capacity is unnecessary at present as at this rate even copper backed tungsten targets will crack in a fraction of a second. There should be some form of quick acting indicating instruments showing Kilovolts maintained on tube terminals and milliamperes of current during the exposure.

In general the lower the penetration the greater the contrast between tissue details and between bones and tissue. Inspection of the energy dissipation curves, however, will show us at a glance how futile it is to try and get results with too low a penetration where any considerable distance of tissue has to be penetrated. For instance at 30,000 volts 8 C. M. or 3 inches of tissue absorbs 99% of the energy in the ray. Another reason limiting us from using low penetration is that the watt seconds of energy necessary to make the exposure become so great as to overheat the tube and lower the vacuum.

The following remarks regarding the various voltages maintained on tube terminals may be of interest.

30-35 K.V. suitable only for hand and chest work on thin subjects where the greatest contrast is desired in tissue details.

35-40 K.V. suitable for general work where distance of tissue to be penetrated is small and great contrast is desired.

40-45 K.V. suitable for bone work where thickness of tissue is under 2 inches. Best for chest work on 100 lb. subjects and for general tissue detail using intensifying screen.

45-50 K.V. suitable for bone work on the extremities and chest work on 150 lb. subjects.

50-60 K.V. best for kidney work on light subjects. May be used on light subjects for bismuth work. Good for general bone work of the extremities.

60-70 K.V. Same as above with increasingly heavier subjects.

70-80 K.V. Only suitable for hip, frontal sinus and bismuth work, unless contrast between details is not desired as plates show considerable loss of contrast.

Perhaps the one most important factor leading toward the best results in Radiography is to know accurately the penetration value of the ray at all times during the exposure since this is necessary to record and reduplicate results.

Now the question which interests the practitioner having a coil or transformer is "How may I readily know something about the value of this penetration factor?"

As far as recording is concerned an image of the Benoist gauge may be radiographed on the plate. This, however, gives us no foreknowledge of the penetration when it is desired to reduplicate previous results unless a series of test plates of the gauge are made and the resistance of the tube adjusted until the desired penetration is reached. This line of procedure is too unhandy for practical use.

Fluoroscopic observations of the gauge are unhandy and somewhat dangerous, furthermore the heat generated in the tube by making them at full current value proposed to use in the actual exposure usually lowers materially the resistance of the tube.

For operators using coils and transformers I would suggest the use of the following device. Construct a ball spark gap whose distance may be adjusted by a handle at the control panel. Equip this handle with a pointer moving a scale which may be calibrated. Make up a water tube resistance to go in series with this spark gap. About four three-foot lengths of a quarter inch bore glass tube, bent in the form of a U, filled with distilled water and connected in series, will answer. This circuit is connected across the tube terminals. To calibrate the scale, start with a tube of rather low resistance and a small current value, make a few flashes adjusting the spark gap to the maximum length that sparks pass continuously.

Note position of the indicator, open out spark gap, make exposure of Benoist gauge on plate, with this current value develop and note gauge reading, mark gauge reading on scale.

Repeat process using increasingly greater current values until the maximum penetration value of the tube with the apparatus is attained.

Then continue with tube of greater resistance until about 9 Benoist is attained.

We now have an instrument from which we may obtain an idea as to the penetration factor of the ray in advance of making an exposure by making a few short flashes and adjusting a handle.

We must bear clearly in mind, however, that any apparatus which allows voltage to fluctuate on the tube terminals when current is flowing through it produces a mixture of penetration which gives a resultant penetration indication on the gauge.

With the same maximum voltage indicated by the spark gap or Heintz-Bauer quality meter a tube which has a high lighting voltage will give a greater resultant penetration than one with a low lighting voltage for the reason that a smaller proportion of the total corpuscles are "fired" at low voltage values.

These inaccuracies are probably not greater than 20% however, due to the fact that about 80% of the action on the plate under parts it is desired to investigate, is caused by corpuscles fired at close to the maximum voltage.

In order to overcome these inaccuracies, an apparatus was constructed which has the ability to maintain an unfluctuating voltage on the tube terminals during all the time current is passing. Under these conditions all tubes having platinum or Tungsten targets give the same penetration factor with a given voltage regardless of their condition, within the limits of error in our present methods of observation.

A system of measurements is in process of being made at the M. G. H. with a view to accurately determine the penetration factor which gives the best detail or technical facilities for the various cases, and secondly the number of milliampere seconds' exposure, or "Corpuscles fired," which gives the best photographic action on the plate with the penetration factor and case in question. It is hoped within a short time these results will be ready for publication and will prove of value to Radiographers knowing the penetration factors of the rays with which they are working.

The present apparatus used is of the nature of a direct current rotary converter having a variable ratio of transformation. It transforms 220 volt direct or alternating current to high potential direct current having a potential fluctuation of only 1½%.

The value of this high potential may be adjusted from 30 K. V. to 100 K. V. according to the value it is desired to maintain on the tube terminals.

It is capable of supplying energy to the tube up to a rate of 15 K. W. It is equipped with a quick acting indicating voltmeter showing the exact number of K. V. maintained on the tube terminals.

The radiographic technique used is as follows: starting with a low current value a few flashes are made, increasing the current until the voltmeter indicates voltage and thereby the penetration factor desired. The milliameter is read and the exposure is timed to have the same number of milliampere seconds as the previous result at this penetration factor it is desired to reduplicate.

If the current value gets too large before the desired voltage is attained a higher resistance tube is substituted. Usually two tubes will suffice to get any penetration factor from 3 to 8 Benoist without changing the vacuum.

Radioscopy:

In order to get enough light through the patient for examining bismuth cases and heart cases at 7 foot distance, without overheating the tube and thus causing the vacuum to fall during the examination, it is absolutely essential to use penetration values of between 7 and 10 Benoist under which circumstances as low a current as about 5 milliamperes will pass enough light through the patient.

Tubes which have such a high resistance as to only pass 5 M. A. when 80 K. V. is maintained continuously on the terminals are in an unstable state of vacuum which is very liable to change quickly. They only reach this condition after much seasoning and are liable to become cranky shortly afterward.

If the usual rectifying transformer is used, in order to prevent overheating and overexposure to the patient we are forced to use a tube in this condition and the unstableness of the vacuum often makes the results very unsatisfactory.

What is needed is an apparatus which has the ability to pass currents of very large amplitude through a tube of normal resist-

ance and thus bank up the desired potential. In order to prevent the tube from overheating under these conditions on account of too many corpuscles being fired per second, it is essential that during, say about 90% of the total time, no current should be passing through the tube and during the remaining 10% of the total time the current passing through should have 10 times the value it indicates on the milliameter.

In the past the only apparatus obtainable which to any extent fulfilled this condition was the induction coil. It is not ideal for the reason that its electromagnetic inertia prevents the current from instantly attaining full amplitude necessary to produce the desired penetration and consequently a portion of the corpuscles produce heat without producing any useful light on the screen, their energy of X light being simply dissipated in the patient.

The quality of X light between 7 and 10 Benoist causes loss of contrast and some operators prefer to work with the same current and lower penetration under which condition it is absolutely essential to get the eyes in the most sensitive state possible on account of the smaller amount of light available on the screen. We cannot use currents of over 10 milliamperes in this work except for short intervals of time without danger of overheating the tube or overexposing the patient.

Perhaps the most essential feature of good Radioscopic technique is the ability to quickly change in the dark the adjustment of the apparatus so as to cause the tube to give out rays of lower penetration value in large quantities so that a good quality plate may be obtained in the middle of an examination or a tissue detail of interest observed with plenty of light and contrast for a few seconds.

Radiotherapy:

This branch of the art has been very much held back by lack of scientific means of knowing, recording and reproducing the exact amount of dosage to which a non-superficial portion of tissue was subjected. The reason of this difficulty is that if voltage on the tube terminals is allowed to vary we get a changeable mixture of penetration values from which it is impossible to determine how the energy dissipation is distributed.

It is hoped that the use of unfluctuating voltage may prove a remedy for this difficulty since it gives us the ability to accurately know and reproduce the same conditions day after day, using different tubes. It should afford a common medium whereby operators might check and reproduce each other's results.

Referring to the distribution of energy curves it is of interest to note that with a given number of milliampere seconds exposure, the amount of energy dissipated in the first millimeter of tissues penetrated, is probably a constant regardless of the penetration factor except in cases where penetration is so low that the walls of the tube absorb an appreciable portion of the energy. This seems to follow if we admit the theory of the German Physicist Max Wein, that the energy of the X-ray is a definite proportion of the energy dissipated in the tube and furthermore that distance, of absorbing medium penetrated which absorbs a stated proportion of the total energy, is proportional to voltage maintained on tube terminals.

Measurements have been made at Mass. Gen'l Hospital to determine the value of the saburoid pastille dosage unit. These gave us 3400 milliampere seconds at 10″ from the target with a penetration factor of four Benoist. On the other hand the amount of energy dissipated in any millimeter of tissue not on the surface, with a given number of M. A. seconds is entirely dependent on the penetration factor. This points towards the advisability of using high penetration where non-superficial tissue is to be treated as in the case of treating malignant disease.

The reason for this seems clear to me. We are limited in the amount of dose we can get to a non-superficial portion of tissue by the fact that we may not overdose the surface tissue without grave results.

Now insofar as we increase the penetration may we increase the value of the dose that the non-superficial portion of the tissue gets before the dose on the superficial portion has attained the limiting amount.

Is it not possible that the reason why the treatment of non-superficial malignant disease has not shown more encouraging results is due to the fact that we have never been able to give the area in question a sufficient dose to affect the cells in the best manner?

In order to obtain more penetrating rays for this purpose it is up to the tube maker and electrical engineer to slip in and help the Radiologist—the one to design a tube of higher puncturing voltage and proper resistance characteristics and the other to devise a form of energy supply capable of giving the desired results with this tube.

Now let us try to imagine the ideal apparatus and technique for general radiology.

One tube in a constant and stable state of vacuum should suffice for a whole morning's work of mixed Radiography, Radioscopy and Radiotherapy. This points toward a water cooled tungsten tube.

The apparatus supplying electrical energy should be so constructed that it maintains on the tube's terminals a definite voltage during every instant of time that corpuscles are being "fired" which may be adjusted to any value between 30 and 100 Kilo volts. The setting of this adjustment should ensure that all rays produced have the exact penetration found from past experience to give the best results for this particular case.. This will relieve the operator from worry about penetration factor.

In order to prevent the tube which should be in a low and stable condition of vacuum, from "firing" more corpuscles per second than is desired we must have a second adjustment of the apparatus that governs the proportion of time when full voltage of definite value governed by the setting is maintained on the tube terminals as compared with the time when no voltage exists on the tube terminals.

This is the only method by which we may govern the current flowing through a tube with a given condition of vacuum without affecting the penetration factor of the rays it is producing.

With this apparatus, without changing the conditions of vacuum of the tube, we may obtain rays of any quality we may desire and in any quantity we desire; the two being separately and independently adjustable.

The one apparatus and tube may, therefore, by moving two handles be set to give the exact kind of ray as regards quality or quantity we have found from past experience to be the best for any given purpose.

Let us now try to imagine a specific instance of technique with this apparatus, which we might hope to attain sometime in the future.

A patient suffering from trouble of the digestive tract is brought by his doctor to the radiologist for examination. The radiologist looks in his records, after noting size of the patient. He finds that the best intestinal plate of a subject of this size was produced by a voltage of 75,000, a current of 100 milliamperes, a time of 1/5 second and a distance from the target of 2 feet, with specified brand of plate, developer and time of development.

A set of plates is made ready to be quickly inserted in place of the fluoroscope screen, the time switch is set for 1/5 second and all three retire to the darkened room while the bismuth meal is being administered. Fluoroscopic examination is started with the quality lever on 90,000 volts to ensure getting enough light through the patient with a small current value. The tube happens to be in a condition of vacuum to cause it to pass 200 milliamperes with 90,000 volts maintained on the terminals. The quantity lever is moved until the desired amount of light is obtained on the screen. The milliampere meter now indicates 5 milliamperes. What really happens is that there is a current of 200 M. A. flowing through the tube 1/40 of the total time and no current at all flowing through the remaining 39/40 of the total time.

A point of interest is noted in the passage of the bismuth. The quality lever is changed to the 75,000 volt position and the quantity lever shifted until the current reaches 100 M. A. Due to decrease in penetration and increase in light everything shows much more distinctly but only a few seconds' examination may be permitted at this rate.

A plate is then slipped in, in place of the screen and the time switch snapped ensuring an exposure of 20 M. A. seconds at 75,000 volts.

From the examination it develops that the patient is possibly afflicted with cancer. In order to try and obtain certain soft tissue details of interest, a plate is put in the intensifying screen. Records show best tissue detail plate made by 40,000 volts 100 M. A. seconds using screen. Penetration control lever is set at 40,000 volts current adjusted to 200 M. A. and time switch set for ½ second. Results from these plates and the fluoroscopic examination reveal a carcinoma so extensive that removal of it is not in question. Now comes the question: Is X-Ray treatment advisable? Perhaps at this hypothetical time in the future we may desire to start right in.

If X-ray treatment seems desirable, the depth of cells from the surface and value of the dosage they have already received in the fluoroscopic and radiographic examinations computed by reference to the dissipation of energy charts. The dosage the skin has already received is also computed.

The patient is then subjected to a given dosage at 200 Kilo Volts to bring the amount of energy absorbed by the tissue in

question up to the normal amount indicated as best from past records.

Tubes as they stand today have characteristics which render this technique possible.

It remains necessary in order to attain it to develop an X-ray tube gun firing apparatus which has the ability to fire just the right number of shots, or just the right number of shots per second, with just the right velocity to best suit each individual case.

Electrically, this means a form of energy supply whose terminal voltage may be adjusted to any desired unfluctuating value and is not materially lowered by sudden rushes of current which may run up to instantaneous values of several hundred M. A.

The current flowing through the tube is governed, not by changing the voltage of the apparatus, as at present, but by the intermittently connecting the tube to the apparatus and varying the proportion of time connected to time disconnected.

This method of governing current is essential if we desire one tube in a given state of vacuum to answer all the purposes of the Radiologist.

This method of energy supply in which current in the tube is governed by varying the proportion of time the tube is maintained at a definite terminal voltage as compared to time it has no terminal voltage has been tried out experimentally at the Mass. General Hospital within the past two weeks by adding a mechanical attachment to the constant voltage rotary converter. The experimental results were found to check the theoretical results predicted and are thus encouraging so far as they have gone.

In conclusion if we keep the voltage from fluctuating during the exposure, and know its value, I believe there is no difficulty in accurately recording and reduplicating best results from all cases where we have a sufficient number of records of best results to work from.

If we allow the voltage to fluctuate during the exposure it has been found from past experience that no system of records is of much use on account of the fact that when we start to make the exposure we do not know with sufficient accuracy just the brand of ray the tube is producing. This must lead in many cases to partial failures necessitating abandoning the case for fear of overexposure before all knowledge which might benefit the patient has been obtained.

COMPARATIVE DENTAL ANATOMY.
X-RAY STUDIES.

BY E. H. SKINNER, M. D., OF KANSAS CITY.

Some comparative dental studies undertaken upon the smaller animals with Dr. Martin Dewey of Kansas City have called forth this presentation before the American Roentgen Ray Society.

It is very interesting to note the manner in which Nature provides proper dental structures to meet the requirements of the different lower animals. The habits and mode of acquiring sustenance among these animals demand an entirely different method of dentition. The animals live just as long as their teeth are capable of performing their function. A man may be as old as his arteries but an animal is just as good as his teeth. There is no dentist among them to bridge vacancies or repair other damage.

Unlike the human tooth which has permanent pulp, many of the lesser animals like the rat, squirrel, beaver, woodchuck, wild cat, antelope, rabbit and buffalo possess teeth with perpetual pulps. That is, as the tooth is worn away by use it constantly grows from a perpetual pulp to replace and maintain sufficient exposure of dental structure necessary for the acquirement of food and for purposes of defense.

These teeth of perpetual pulp must accurately oppose each other so that they are all worn away regularly and if one tooth is lost through accident or injury the opposing tooth continues to grow. The unopposed growth of a tooth will eventually result in the inability to close the jaw. Therefore the animal dies from starvation because of inability to acquire and masticate food or failure to defend himself against attacks.

Some of these animals have anterior cutting teeth which have a persistent pulp located far behind the other teeth of the jaw in the ramus. This long tooth occupies a long cavity the entire length of the horizontal ramus. This is seen in the beaver, (Fig. 8).

Other animals have short teeth of persistent pulp which are not much different in shape from a human tooth.

Fig. 1. The Squirrel Mandible.

The dentition of the squirrel is characterized by the large scalpriform (chisel) incisors, a right and left central. These teeth grow from persistent pulps, and the enamel is thicker on the labial than on the lingual side which permits the teeth to be always worn to a sharp edge. The tooth is also curved which permits great force to be brought to bear on the cutting edge of the tooth, and does not transmit the force directly to the persistent pulp. The molars and premolars do not grow from persistent pulp and are therefore like the teeth of man. The root exceeds the length of the crown and is therefore classed as a brachydont tooth.

Fig. 2. Skull of squirrel which shows the arrangement of the upper incisor and the molars and premolars. The circle of the upper incisors makes an arch of a smaller circle than the lower teeth. It is well to note from a comparative point the dovelet length of the teeth of the squirrel, beaver, woodchuck and rabbit.

Fig. 3. The skull of a squirrel which has lost the lower tooth and as a result of this loss there was nothing for the upper tooth to occlude against. Therefore the tooth continued to grow until the animal died from starvation.

Fig. 4. Woodchuck which has dentition very much like the squirrel except the incisor is not as long as compared to the size of the animals. The woodchuck does not feed on a diet which requires as great use of the anterior teeth as does the squirrel, therefore the teeth are not as well developed.

Fig. 5. The teeth of the wild cat are brachydont. The canines are highly developed for prehension and as a weapon of warfare. The incisors are small and are used as bone scrappers. The function of cutting the food is performed by the sectorial molars and premolars, which have the cusps arranged in rows form before backward. The condyle is long, the buccal to the lingual and short nesio-diatally, which gives the mandible only an up and down movement.

Fig. 6. A comparison of the woodchuck, wild cat and antelope. The teeth of the antelope are hypsodont. The length of the crown is greater than the root. As the crown is worn off the tooth elongated, but no more dental tissue is formed at the end of the root as in the tooth of persistent growth in the squirrel.

Fig. 7. One half of the jaws of the buffalo which had lost an upper tooth. The opposing lower tooth was not worn off, which

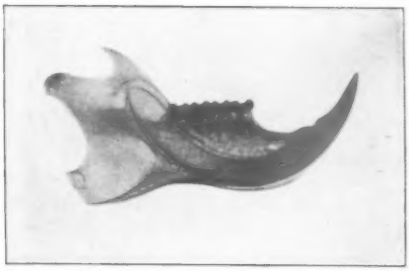


Fig. 1. Squirrel Mandible.

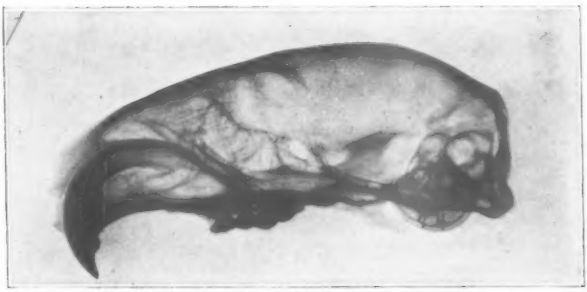


Fig. 2. Skull of Squirrel.

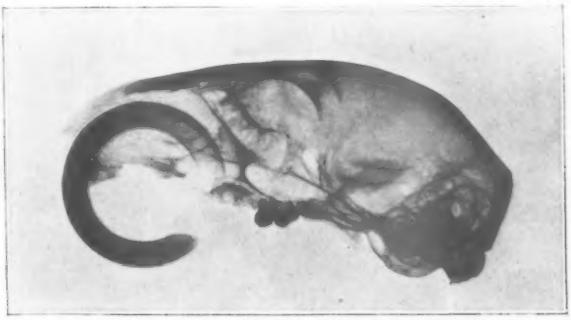


Fig. 3. Skull of Squirrel.

Roentgenograms by
Dr. Skinner, Kansas City.

Fig. 4. Woodchuck.

Fig. 5. Wildcat.

Roentgenograms by
Dr. Skinner, Kansas City.

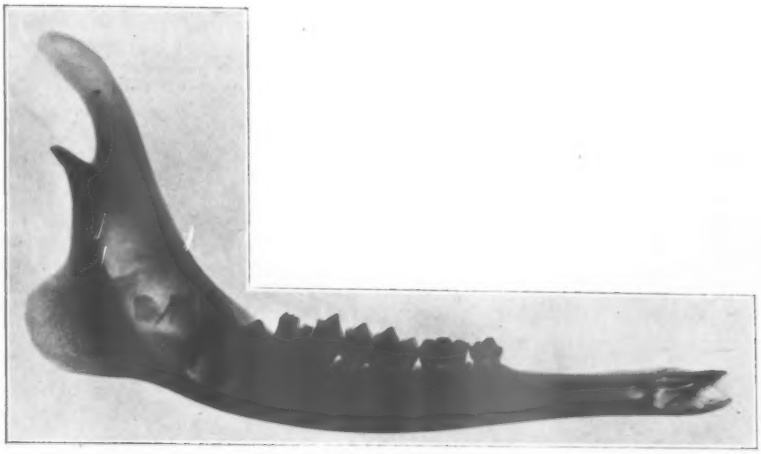


Fig. 6. Antelope.

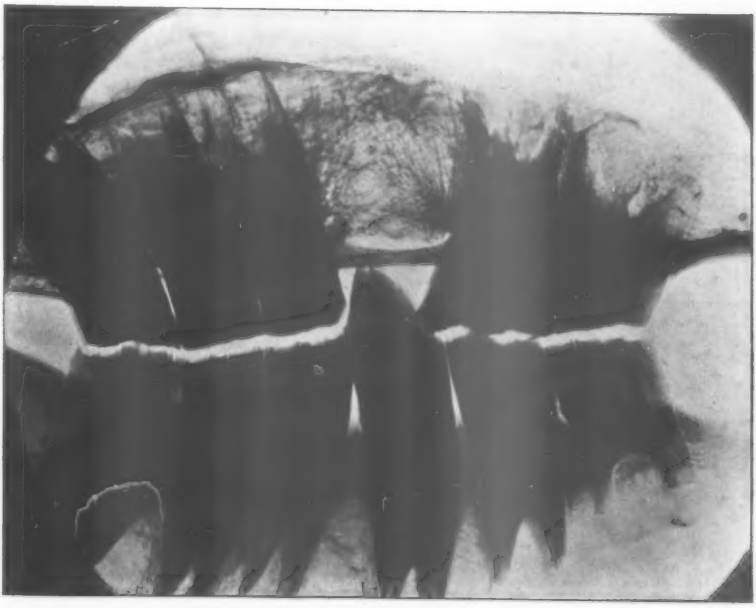


Fig. 7. Buffalo.

Roentgenograms by
Dr. Skinner, Kansas City.

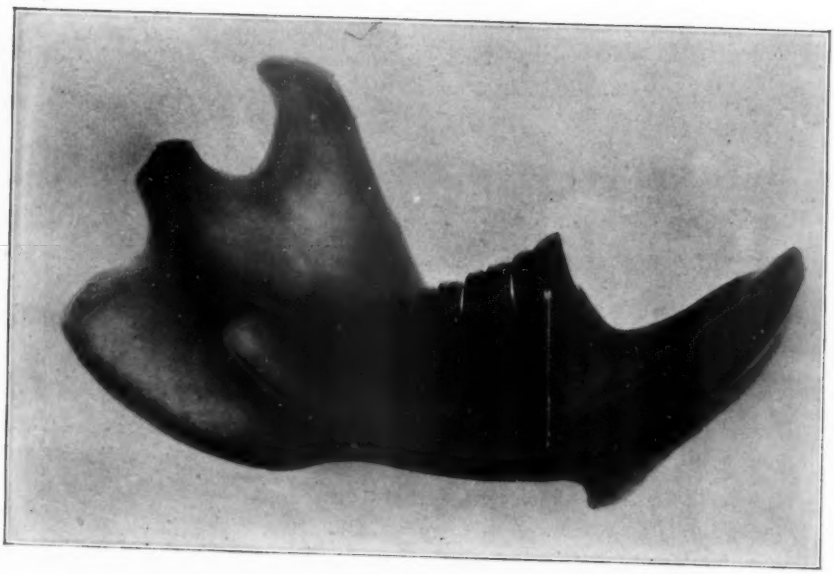


Fig. 8. Beaver.

Roentgenogram by
Dr. Skinner, Kansas City.

shows the crown projecting up into the vacant space. The other upper and lower teeth have been worn off as much as the one shows elongation. Note the arrangement of the spiculæ of bone to support the two teeth on each side of the one that is missing.

Photographs of rabbit skulls which can be used to show the value of the X-ray in studying the length of the root. There is nothing in the skull that would suggest the great length of the root unless one has investigated it before hand.

A SLIDING DIAPHRAGM FOR IMPROVING THE QUALITY OF SKIAGRAPHS.

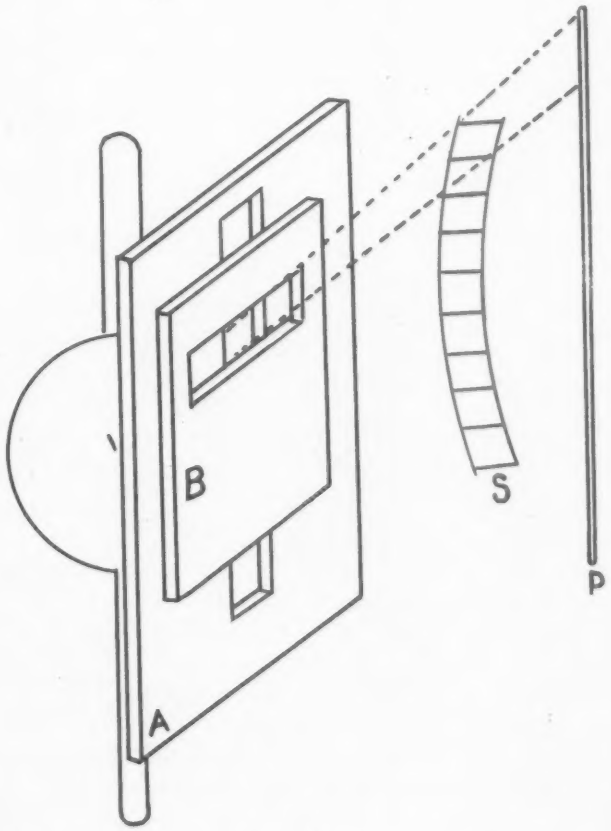
BY A. HOWARD PIRIE, MONTREAL.

A skiagraph made with a small diaphragm is sharper than one made with a widely open diaphragm. If we could expose a 14″ x 17″ plate with a small diaphragm which would expose it by consecutive square inches, the whole skiagraph would be as sharp as it is possible to get it. The diaphragm about to be described, is constructed to attain that object. It was primarily constructed for getting better detail in the vertebral column, but it is also applicable for sharpening the detail in all skiagraphs.

For example, to get a very sharp skiagraph of the spine, a stationary diaphragm is arranged so that the spine appears on the plate and the soft parts on each side are blocked out. This diaphragm is a long slit 5″ long by 1″ broad and is stationary. In front of this is another slit shaped diaphragm with its slit at right angles to the slit of the first. This second diaphragm is a sliding one which runs in the direction of the slit of the fixed diaphragm. The moving diaphragm has an aperture 4″ long by ½″ broad. Suppose we take a skiagraph of the spine from the first cervical to the last dorsal vertebra. The fixed diaphragm shows the whole spinal region at once. Now put on the sliding diaphragm so that the two (diaphragms) together expose only the first cervical vertebra. Begin the exposure and set the sliding diaphragm in motion, so that it slowly travels over the fixed diaphragm. On looking at the fluorescent screen (placed above the plate) one sees each vertebra from the first cervical to the last dorsal appearing one after the other. Each vertebra is thus taken with a diaphragm 1″ x ½″ and therefore each vertebra is much sharper, than if the whole spine had been taken with a widely open diaphragm. Certain parts of the spine are denser than others, and at these parts the sliding diaphragm is made to move more slowly and thus the whole spine gets the most suitable exposure. To expose a 14″ x 17″ plate of the abdomen for a barium injected colon, the fixed diaphragm is opened, so as to include the whole abdomen. The sliding diaphragm shows at the top of the plate a strip 14″ x 2″ and this strip gradually travels

to the other end of the plate, as the sliding diaphragm slides over the fixed diaphragm, and thus the whole plate is exposed.

The exposure is, of course, longer than that required by the ordinary method, but by using an intensifying screen the exposure does not exceed that required for a skiagraph made without an intensifying screen, and the result is much superior. No trace of the travelling diaphragm can be seen on the skiagraph. Both diaphragms are of thick lead and are arranged as close to the tube as possible without touching the glass. The diagram shows the principle described. I use the arrangement over the tube under the X-ray couch.



A—Fixed diaphragm. B—Sliding diaphragm. S—Spine. P—Plate.

A METHOD FOR REMOVING THE DISCOLORATION FROM STAINED ROENTGENOGRAMS.

BY V. AAGAARD, BATTLE CREEK, MICH.*

Roentgen workers are frequently chagrined to find valuable Roentgenograms discolored during forced development of an under-exposed plate. For purposes of exhibition and when accurate copies are desired, it is possible to remove these stains completely without reducing the Roentgenogram which is usually already too thin. The formula consists of two solutions:

Solution A: One ounce of saturated solution of potassium permanganate in eight ounces of water;

Solution B: One ounce of potassium metabisulphate in eight ounces of water.

The Roentgenogram to be treated must be washed thoroughly until it is free from hypo. If it has been dried, it should be soaked up again. Two trays are required, one for each solution.

Immerse the plate in Solution A for four or five minutes, agitating the solution constantly by rocking the tray. Then remove the plate and rinse it well. On removing the plate and rinsing it, it will be found stained the characteristic color of permanganate, but after being left in Solution B from two to three minutes and again rinsed, it will be found perfectly clear. It is very important that the surface of the plate should be rubbed with a tuft of cotton dipped in water after being removed from Solution A and before it is placed in Solution B to be sure that all the chemicals are removed from the film, otherwise some stain may be left.

If the negative is especially discolored, the stain may not all be removed by the first treatment. After washing the plates for about thirty minutes in running water in the usual manner, the treatment may be repeated with success. This process does not soften the film as the potassium metabisulphate is a well-known hardener for fixing baths.

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*Contributed from the Roentgen Department of the Battle Creek Sanitarium (James T. Case, M. D., Director).

Calculus in submaxillary salivary gland.

Calculus in submaxillary salivary gland.

Roentgenograms by
Sidney Lange, M. D., Cincinnati, Ohio.

Tumor of Head of Pancreas. The patient was a middle-aged male who presented himself for examination because of distress after eating, which was relieved by vomiting. Gastric analysis negative. Palpation revealed a small mass in the epigastrium. The X-Ray plate shows an obliteration of the pyloric part of the stomach due apparently to pressure from without. The first part of the duodenum is unfilled. The second part is indicated by a thin streak of bismuth, while the third part is well distended. The duodenum apparently encircles the tumor and thus outlines it. (Cf. tumor of tail of pancreas.)

Roentgenogram by

Sidney Lange, M. D., Cincinnati, Ohio.

Tumor of Tail of Pancreas. Male, aged 50. Indefinite gastric symptoms and a tumor mass in the epigastrium. X-Ray plate shows displacement of the lesser curvature of the stomach to the left. A large round mass is apparently impinging on the lesser curvature, giving the stomach a crescent shape. Operation revealed a cyst of the pancreas.

Roentgenogram by
Sidney Lange, M. D., Cincinnati, Ohio.

Organic hour-glass Stomach, due to chronic ulcer of lesser curvature. Also ptosis of transverse colon.

Roentgenogram by
Sidney Lange, M. D., Cincinnati, Ohio.

Extensive Carcinoma of greater curvature of Stomach, producing a peculiar distortion approaching the hour-glass constriction.

Roentgenogram by
Sidney Lange, M. D., Cincinnati, Ohio.

Carcinoma of Caecum. The barium enema failed to enter caecum. When the barium meal was given there was stasis of the same in the terminal coils of the ileum. The patient was a middle-aged female whose chief complaint was recurring attacks of nausea and vomiting. There was no complaint referable to the colon. Physical examination revealed a small movable tumor mass in the right inguinal region which was thought to be the kidney. Operation revealed an extensive carcinoma encircling the caecum. The vomiting was apparently of reflex origin or due to the ileal stasis.

Roentgenogram by

Sidney Lange, M. D., Cincinnati, Ohio.

Adeno-carcinoma of Rectum. Note the constriction about 1½ inches long in the ampulla of the rectum. The calibre of the passage is reduced to the size of a little finger.

Roentgenogram by
Sidney Lange, M. D., Cincinnati, Ohio.

Cyst of Frontal Lobe of Brain. The patient was a girl aged 10 years, who two years previously had suffered a blow upon the forehead. One and a half years later she developed dizziness, occasional vomiting, headache and an external strabismus of the right eye. The X-Ray plate revealed an area about the size of a plum in the frontal bone (right side) where the bone was almost paper-thin. The absorption was progressing from the inner surface of the skull and external table was bulging slightly.

X-Ray Diagnosis—Tumor of the frontal lobe exerting pressure on the inner surface of the frontal bone.

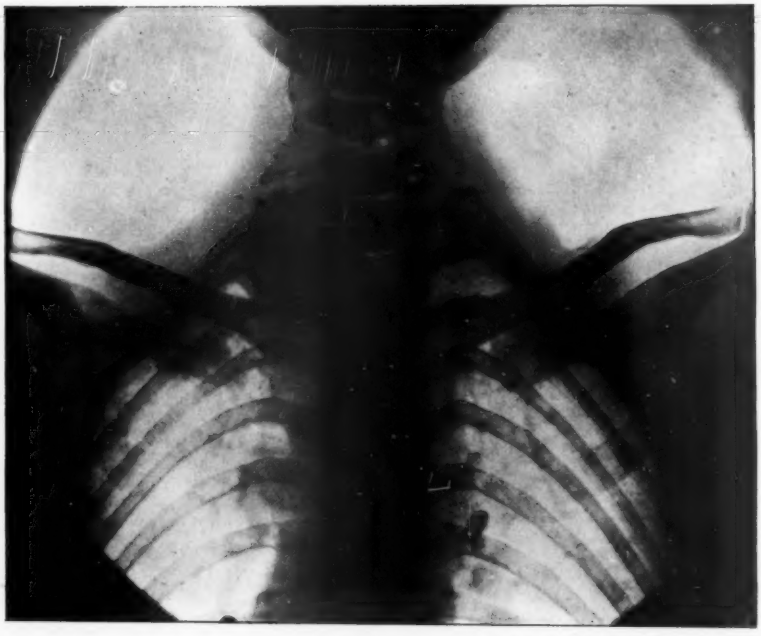
Operation revealed a small cyst of the frontal lobe containing a clear straw-colored fluid.

Roentgenogram by
Sidney Lange, M. D., Cincinnati, Ohio.

Unerupted Third Molar imbedded in outer wall of Antrum. The patient was a girl aged 17 years, who developed a painful tender swelling over left antrum. The cavity of the antrum was uninvolved and several upper teeth on that side had been extracted with a view to locating the cause of the swelling.

Operation revealed a large molar imbedded in a mass of necrotic bone, necessitating the removal of the entire outer wall of the antrum.

Roentgenogram by
Sidney Lange, M. D., Cincinnati, Ohio.



Osteoma noticed four years previously, giving the symptoms of a cervical rib and probably developing from that embryonic source.

Roentgenogram by
Hollis E. Potter, M. D., Cincinnati, Ohio.

Typical Charcot's disease of lumbar spine (rare).

Roentgenogram by
Hollis E. Potter, M. D., Cincinnati, Ohio.

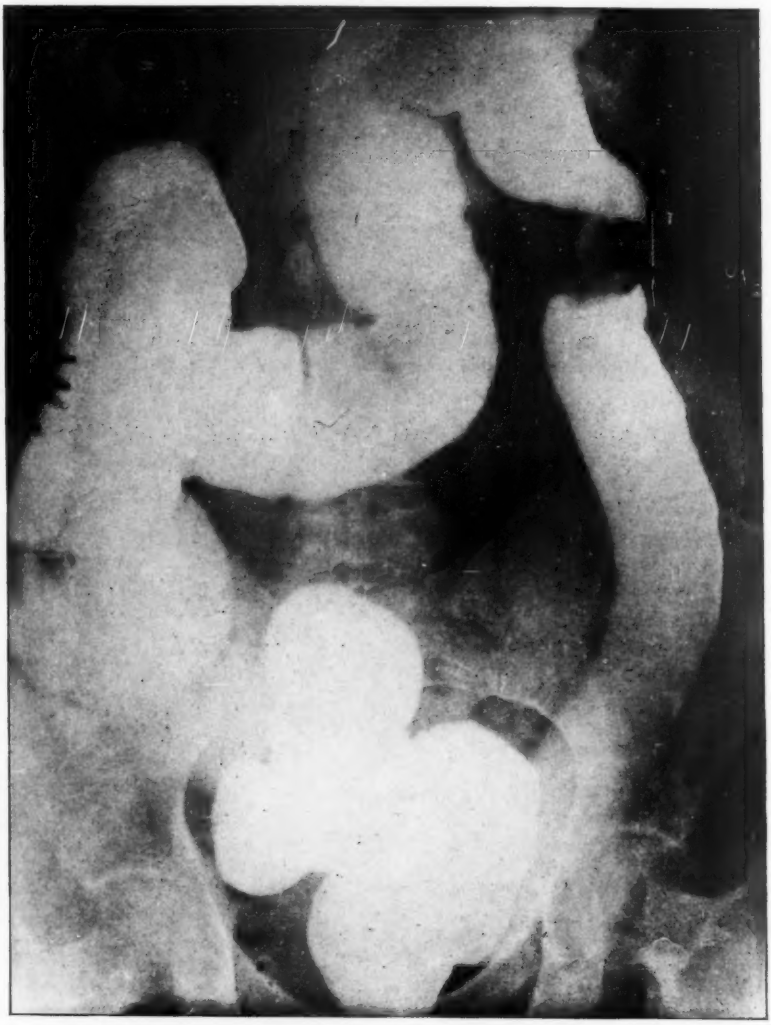
Vesical Calculus containing pin. (Patient face down.)

Roentgenogram by
J. E. Shorb, M. D., Canton, Ohio.

Pin in appendix (before operation).

Appendix with pin protruding, after removal.

Roentgenograms by
J. E. Shorb, M. D., Canton, Ohio.



Female, aged 53. Chief complaint, diarrhoea. Examined seven or eight years ago for hemorrhage from bowel, which she has had occasionally for 30 years. Has occasional pain under left costal arch in axillary line which moves upward. Much trouble with bubbling of gas. General condition good. No palpable tumor.

X-Ray findings: Marked filling defect in descending colon just below splenic flexure, the narrowing being concentric and the lumen reduced to the size of a lead pencil.

X-Ray diagnosis: Tumor of the colon.

Operative findings: Napkin ring carcinoma in splenic flexure of colon, deeply situated and very adherent. Some glandular involvement.

Pathologic report: Carcinoma.

This case is extremely interesting, as the diagnosis was based almost exclusively on the X-Ray findings.

Roentgenogram by

Russell Carman, M. D., Rochester, Minn.

Stomach trouble for the last eight months. Operation elsewhere October, 1912. Nothing found except adhesions.

Acids, total acidity, 12. Free Hcl. 0. Combined acid, 12.

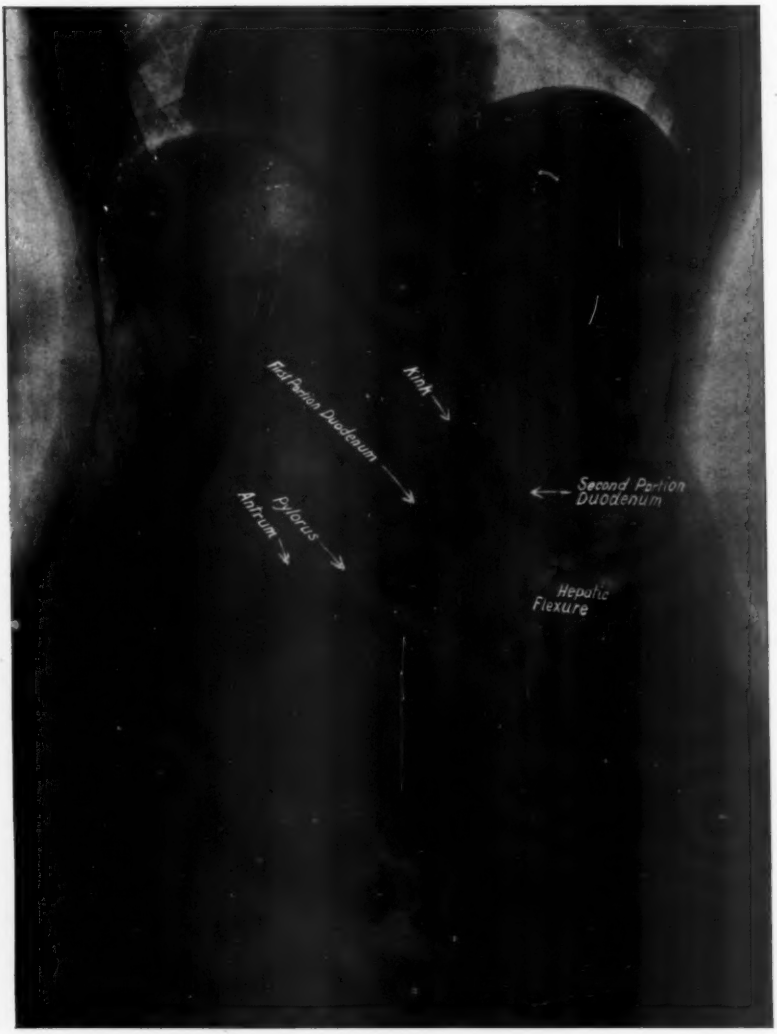
X-Ray findings: Large fishhook stomach, showing projection on lesser curvature posteriorly with deep incisura in middle of vertical portion of stomach opposite projection on lesser curvature. Marked residue after six hours.

X-Ray diagnosis: Large callous ulcer stomach, lesser curvature, posterior wall.

Operation: Large callous ulcer stomach, lesser curvature, posterior wall. Crater of ulcer as large as a nickel, with extensive adhesions to liver. Gastro-enterostomy difficult on account of adhesions to posterior wall of stomach.

Roentgenogram by

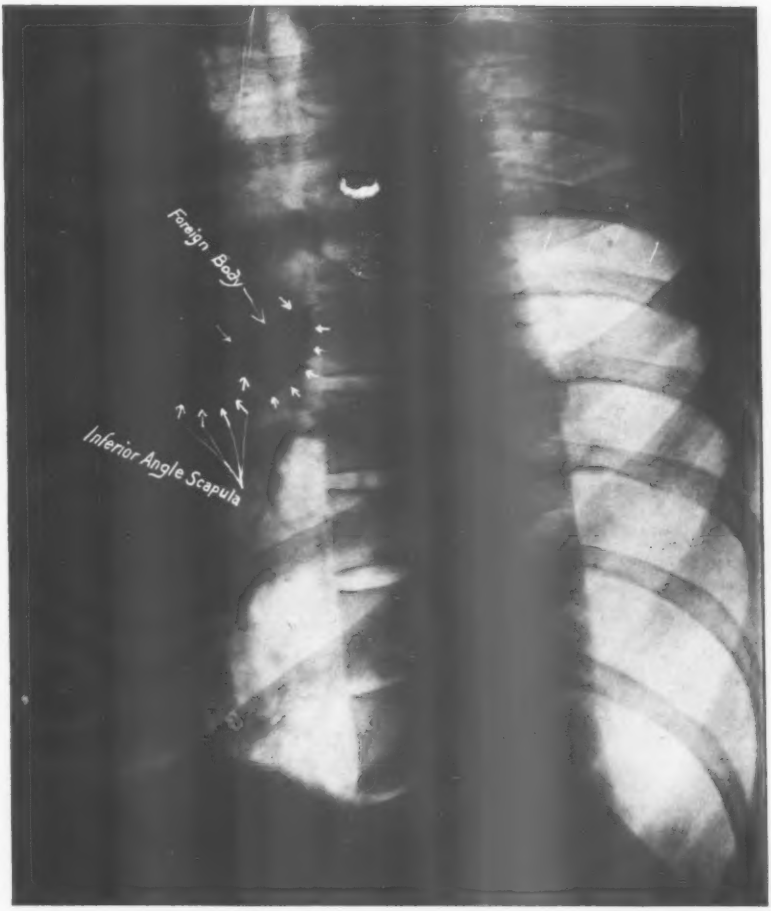
Russell Carman, M. D., Rochester, Minn.



Typical Kink of Duodenum in a case of Gastroptosis. Miss McL. 35 years. Nurse. (Referred by Dr. Earl P. Lothrop.) Record made six hours after bismuth meal. Recumbent position. Stomach contains large amount of bismuth meal, displaced to left of median line and shows poor motor activity. Imperfect filling of antrum. Pylorus not distinct due to traction. Normal duodenal cap absent and in its place is seen an elongated and dilated first portion of duodenum which is not heavily filled by bismuth. Kink of duodenum readily seen and which is evidently due to traction on the duodeno-hepatic ligament. Second portion of duodenum shows some bismuth passing through it.

Roentgenogram by

Leonard Reu, M. D., Buffalo, N. Y.



Foreign Body in Oesophagus. Patient, aged 34. (Referred by Dr. Charles Banta.) While eating a meal was suddenly seized with pain followed by shock. Treated two weeks for cardio-spasm, at the end of which time the patient developed a temperature. X-Ray record made (July 30, 1913) three weeks after the accident showed a foreign body of unusual size located on a line with the inferior angle of the left scapula. The foreign body was clear cut and defined. Records were made every three or four days. The record made Aug. 28, 1913, showed the foreign body absent because on Aug. 27, 1913, the foreign body, a piece of tin measuring 1¼ inch by 1 inch, had passed per rectum.

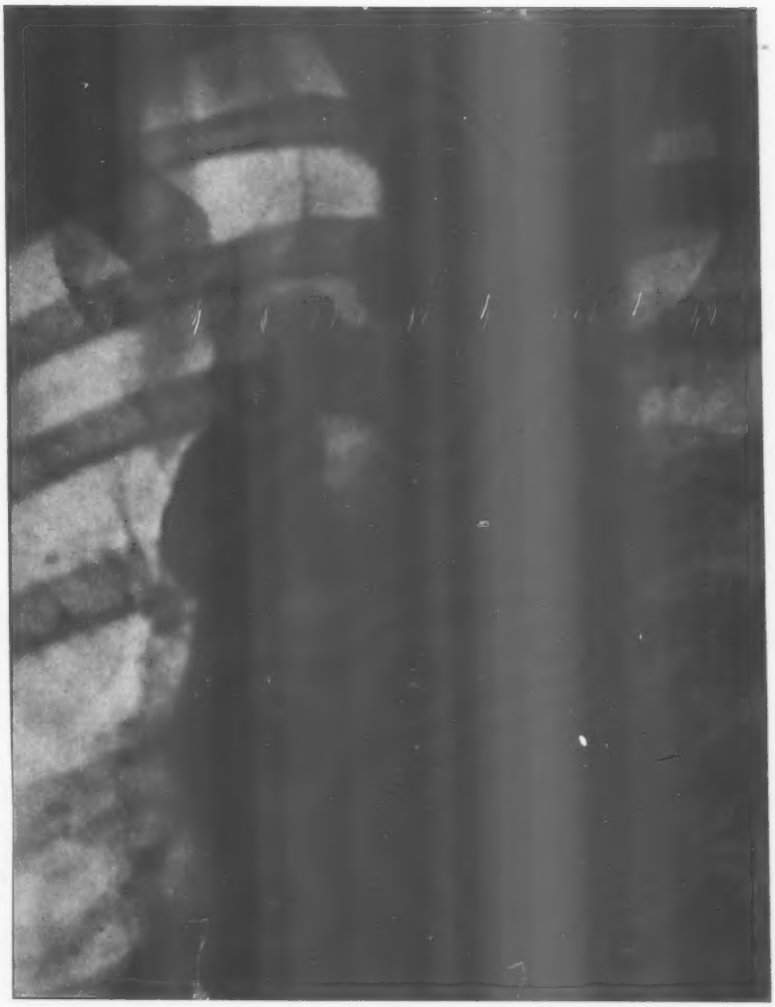
Roentgenogram by

Leonard Reu, M. D., Buffalo, N. Y.

Woman, aged 24, was examined by an internist, who made his own fluoroscopic examinations. A shadow on the right side, in the region of the aorta, was found which was diagnosed aneurism. This diagnosis was subsequently verified by two other men who made X-Ray examinations.

Roentgenogram by

Chas. F. Bowen, M. D., Columbus, Ohio.



(Diagonal view)

The patient had been told of the causes and dangers of aneurism and was indeed in very bad condition mentally, when the original plates were brought to the author for interpretation, anterior views only having been made. As soon as the size, location, shape and mottled condition of the tumor mass were observed, a diagnosis of calcarious gland was at once made.

In order to prove to the patient's satisfaction that the case was not one of aneurism, a diagonal view was made, which shows the gland lying at least one inch from the aorta.

Roentgenogram by

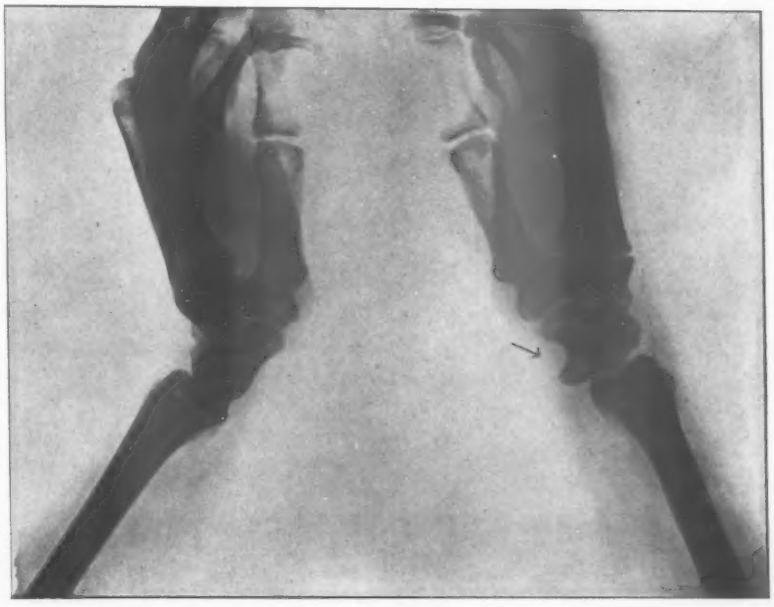
Chas. F. Bowen, M. D., Columbus, Ohio.

Woman, aged 60 (with rheumatism in the right shoulder for some time), received a slight injury which resulted in a fracture of the upper end of the humerus. The patient was brought to the hospital and put to bed; while being lifted by the nurse, so as to insert the bed pan, patient sustained a fracture of both femurs above the knee. Radiographs were taken of the shoulder and both femurs, which revealed a multiple osteo-sarcoma.

The above radiograph illustrates well the condition, not only showing the destruction of bone, but also the tumor mass.

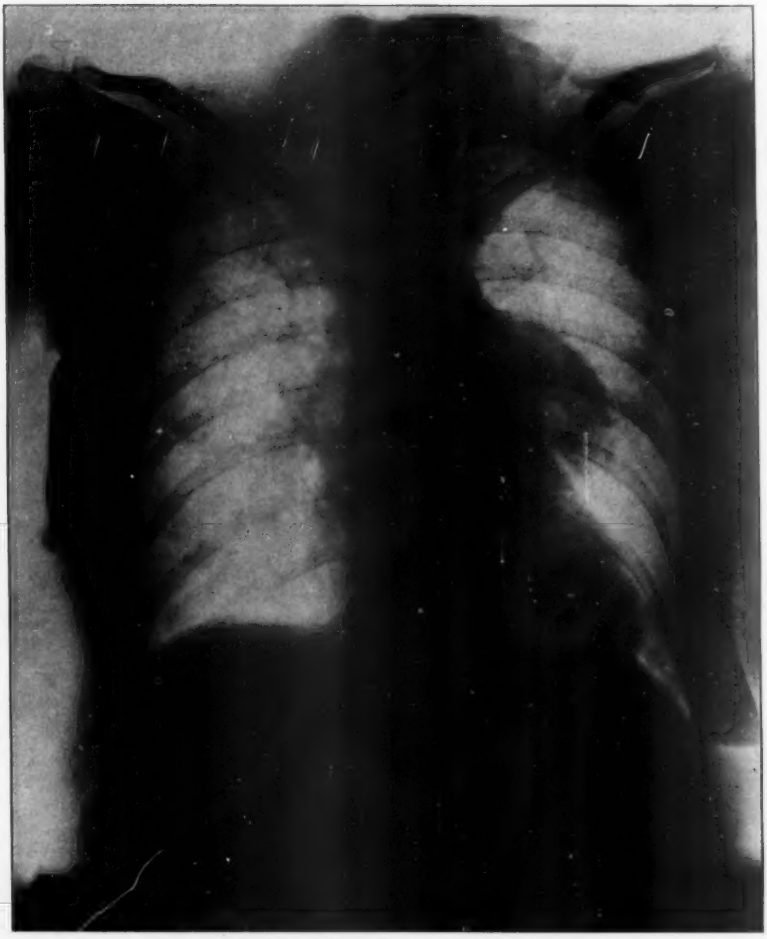
Roentgenogram by

Chas. F. Bowen, M. D., Columbus, Ohio.



Woman, aged 30, injured her wrist in a comparatively slight accident; this was very painful and treated as a sprain, but did not do well. Radiograph was made, which revealed a dislocation semilunar.

Roentgenogram by
Chas. F. Bowen, M. D., Columbus, Ohio.



Case of metastatic carcinoma about the root of the right lung secondary to carcinoma of the breast. (Autopsy.)

Roentgenogram by
James T. Case, M. D., Battle Creek. Mich.

Case of multiple gall stones. More than seventy gall stones were found in this case. (Operative proof.)

Roentgenogram by

James T. Case, M. D., Battle Creek, Mich.

Adherent appendix, filled with bismuth. (Operative proof.)

Roentgenogram by
James T. Case, M. D., Battle Creek, Mich.

Case of acute small intestine obstruction. Bismuth ingested six hours before the plate was made, at which time the patient was vomiting fecal matter. (Operative proof.)

Roentgenogram by
James T. Case, M. D., Battle Creek, Mich.

ABSTRACT REPORT OF THE PROCEEDINGS OF THE SECTION ON RADIOLOGY AS PUBLISHED IN THE BRITISH MEDICAL JOURNAL.

RADIOLOGY

The Section of Radiology is a newcomer in the programme of an International Congress of Medicine, but it proved a lusty infant, and as many as 200 members must have been assembled in the Geological Theater of the new School of Mines on Wednesday afternoon, when the session was opened. The French workers in this branch of medicine were particularly in evidence, perhaps the best known among them being Professor J. Bergonié, of the University of Bordeaux. The other side of the Atlantic also was strongly represented. A hearty welcome to all and sundry was extended by the President of the Section, Sir James Mackenzie Davidson, who, in a very brief introductory address, pointed out how vast a field had been opened up to medicine by the discoveries of Roentgen, Becquerel, and the Curies. It might be said of radiologists that they employed the minutest vibrations in the ether of space for the diagnosis and treatment of disease. An instance of the increasing value of the X-rays purely as a method of examination was afforded by the extraordinary precision which was now possible in the localization of foreign bodies, especially in the eyeball and orbit. The stereoscopic picture in this connection had proved itself of immense service, and although stereoscopy did not enjoy the wide following it deserved, it would ultimately commend itself, he felt sure, in connection with the fluoroscope, even for the examination of the intestine, with the aid of the bismuth meal. An exhaustive paper was read by Dr. James T. Case, who as roentgenologist at the Battle Creek Sanitarium in Michigan, has had large opportunities of studying the X-ray intestinal picture. Indeed, one of his American colleagues said of him in the course of the discussion that he was accustomed to sit before the fluorescent screen for eight hours nearly every day, examining bismuth cases. Dr. Case said that during the last thirteen months he had made a Roentgen examination after a bismuth meal in some 1,500 individuals. Dr. Case's paper, and perhaps even

more his lantern demonstration, brought out many interesting points in connection with colonic peristalsis and antiperistalsis. In the majority of cases in which he had observed antiperistalsis, the picture was that of successive waves originating in the transverse colon near the hepatic flexure; they had never been seen to proceed clearly to the tip of the caecum, but only to a point corresponding approximately with the ileo-caecal junction. He had seen at one time as many as five antiperistaltic waves between the caecum and the middle of the right half of the transverse colon. Perhaps the most interesting section of the paper was that which concerned the author's observations of incompetence of the ileo-colic valve. He had found this to occur in a certain constant percentage. Out of a series of 200 gastro-intestinal cases, 33 showed this incompetency by the barium clysma. In the light of existing knowledge of the functions of the ileo-colic valve, he thought it reasonable to believe that those cases in which rectal alimentation had proved successful were the cases of ileo-colic valve incompetence. Under ordinary conditions the valve acted as a sufficient barrier, so that any attempts to introduce fluid beyond it, either for diagnosis or treatment, were unsafe and unjustifiable. These conclusions with regard to the ileo-colic valve were supported by Dr. Lewis G. Cole of New York, who said that during the last four years he had recognized about 60 cases of ileo-colic valve insufficiency. In his reply upon the discussion, Dr. Case added the interesting point that although diarrhoea had been considered the cardinal symptom of ileo-colic valve insufficiency, the X-ray studies, covering about 250 cases, had shown that, instead of diarrhoea, intestinal—and more especially ileal—stasis prevailed. Three papers were read on radio-therapeutic subjects, the first by Dr. Béclère, describing his technique in the treatment of leukaemia, and the other two, by Dr. J. Belot of Paris, and Mr. C. R. C. Lyster of London, detailing their personal experiences in the X-ray treatment of exophthalmic goitre. Dr. Belot considered that it was always to an alteration of the glandular function and of the gland itself that this condition must be attributed, and that the special action of the X-rays on the glandular elements justified the radio-therapeutic procedure. He used an aluminium filter of 1½ mm. in thickness, and obtained his results without producing any lesion of the skin. Out of 30 cases treated only 5 showed

no amelioration, but, on the other hand, only 8 showed a diminution of the goitre, and only 6 a diminution of the exophthalmos. Mr. Lyster, in the course of his paper, said that he was unable to state with certainty the sequence in which the symptoms decreased, but, so far as he had been able to observe, the rapidity of the heart's action was lessened, tremor disappeared, and the general excitability of the nervous system became less marked. He had treated a few patients who were suffering from the disease in the acute form, and in these the vomiting and diarrhoea ceased, the heart's action diminished at once, and the condition generally changed from the acute to the milder type. The two papers initiated an interesting discussion, in which there was a good deal of interchange of experience, favorable on the whole to radio-therapy, though it was suggested that the data were as yet inadequate for a definite conclusion, and that such data as were available were sometimes perplexingly inconsistent.

RADIOLOGY

Radiography of the Stomach and Intestines

Two exhaustive reports on the radiography of the stomach and intestines were available for discussion at the morning session, on Thursday, but unfortunately both authors, Dr. C. Lester Leonard of Philadelphia, and Dr. G. Holzknecht of Vienna, were prevented from being present by reason of illness. This was particularly lamentable in the case of Dr. Leonard—the sage of American Roentgenology, as one of his compatriots called him—for the reason that his illness was due to the effects of over-exposure to the rays. It was felt worthy of chronicling as another instance of heroic devotion to medical science that he should have deferred undergoing a necessary operation for six weeks in order that he might complete his report to the Section, which was read in his absence by Dr. H. K. Pancoast, also of Philadelphia.

The technique of the opaque meal in gastric and intestinal examinations figured largely in both reports. Dr. Leonard urged the special suitability, on scientific grounds, of the oxychloride of bismuth, although pure barium sulphate offered a more economical substitute for routine administration. Oatmeal porridge commended itself to him as the most suitable medium for the opaque meal, but he suggested, as

did also Dr. A. F. Hertz in the subsequent discussion, that a standard opaque meal should be established, and that if possible the standard should be made international. Dr. Holzknecht made the point that if barium sulphate were the opaque salt employed, care should be taken to obtain the chemically pure preparation (*chemice purissimum, ad usum internum*), other barium salts being injurious.

Several radiologists expressed decided views on this question. Dr. Lewis G. Cole, of New York, pointed out that an artificial precipitate of barium sulphate was much more flocculent than many of the chemically pure products, and therefore was held more readily in suspension. In his judgment the more usual media, such as porridge and bread and milk, did not allow a sufficiently fine suspension of the salt to give the detail necessary for the differential diagnosis of gastric and duodenal lesions, and, on the other hand, were more rapidly digested than a regular meal, and failed to give an accurate index of the motor efficiency of the stomach. His preference was for thick buttermilk, as this allowed the bismuth or other salt to pass into the crevices and between the rugae, thereby affording the necessary detail in the picture; this should be followed by a regular meal, in order to determine the motor efficiency. Perhaps the point of chief practical interest was contributed by Dr. A. Howard Pirie, of Montreal, who described a simple procedure for removing the chemical taste of the barium sulphate as well as the grit usually present, and any soluble poison which might be accidentally involved in the barium preparation. Placing about 10 pounds of barium sulphate in an earthenware pot, he mixed it with a gallon of very hot water. After a period of twelve or twenty-four hours the mixture settled with the grit at the bottom of the pot, above the grit a fine mud, and above this again clear water. The clear water was poured off, and the topmost layer of fine mud was used for the day's work. At the end of the day the mixture was prepared again in the same manner for the following day's use. Dr. Pirie claimed that this procedure removed from the meal at once its possibilities of danger and also its unpalatableness, for the barium could then be mixed with milk in such a manner that the patient was unable to recognize it.

Many interesting points in connection with the intestinal movements were brought out in the reports. Dr. Holzknecht

drew special attention to the largeness of the movement with which the greater part of the food normally passed along the colon—a phenomenon seen at its best when a regular meal was given some hours after the bismuth or barium repast. Both reporters referred to the radio-cinematographic method of illustrating the process of digestion. Dr. Leonard was of opinion that while the movements within the alimentary canal could be most effectively studied by means of bio-roentgenograms, the apparatus was too expensive to allow it to become of general service at present. Expense notwithstanding, roentgenography already owed to this method knowledge which could be obtained in no other manner. The study of the peristaltic waves of the stomach by laying the cinematographic principle under tribute had elucidated the sequence of the movements and shown the variation in depth during the passage of the waves down the stomach.

SERIAL RADIOGRAPHY

A demonstration of one method of radio-cinematography was given on Thursday afternoon by Dr. Lewis G. Cole. The film he projected was certainly remarkable, as it showed plainly the phenomena of stomach evacuation. The immediate purpose of Dr. Cole's communication was to illustrate some points in the diagnosis of duodenal or, as he preferred to call it, post-pyloric ulcer. The differential diagnosis of ulcer in the first or ascending portion of the duodenum, or the cap of the stomach, from malignant gastric conditions formed, in Dr. Cole's words, "one of the firing lines of surgical advance." The method of diagnosing post-pyloric ulcer which he had employed in 500 cases was based on the recognition by the cinematographic method of a constant deformity of the cap or sphincter, caused by the induration or cicatrical contraction surrounding the crater of the ulcer. This could be recognized, he said, by studying individually and collectively a large number of plates, and either matching them over each other, or preferably reproducing them on the cinematograph film. Although he had obtained the perfect illusion of movement, Dr. Cole hesitated to apply the term "cinematographic" to such reproductions, but he preferred to call them examples of serial radiography, and he considered that from the diagnostic point of view much more was to be learnt from a number of instantaneous radiographs of different phases in different cycles than from the same number of radio-

graphs of different phases in one cycle, as in the direct, continuous cinematograph picture. He described serial radiography as the "most active scout" in the detection of ulcers of the stomach cap.

Another radio-cinematograph record of the stomach, the result of instantaneous exposures made at the rate of rather more than one per second, was shown by Dr. A. H. Pirie. The motions on the screen were more rapid than in nature, of course, but there was sufficient sequence to suggest the value of the method.

Dr. Pirie also read a paper on a correlated subject—namely, the variation in the appearance of the normal stomach as seen by X-rays, in which he pointed out the importance of examining the whole of the intestinal tract, as symptoms which were referred to the stomach might arise from other causes. In one instance the stomach symptoms disappeared after the removal of the appendix, which had retained the barium for as long as forty-three days after the administration of the meal.

EXAMINATIONS FOR STONE

Another application of the X-rays in diagnosis was illustrated by Mr. C. Thurstan Holland's statistical paper on X-ray examinations for stone. The total number of such cases which had come under his care during the past eight years was 1,707, and of these 104 were for bladder examination only. He gave some useful figures showing the proportion of occurrences of pelvic shadows, calcareous glands and arteries, deformities, and so forth. Calculi were found in males in 276 cases out of 985 examined, and in females in 126 out of 618. His youngest case was a boy of 5 years, in whose kidney six stones were found.

POST-OPERATIVE TREATMENT OF MAMMARY CANCER

The remaining paper on the day's programme was on a radio-therapeutic subject—namely, the treatment of recurrences and metastases from carcinoma of the breast. The author, Dr. George E. Pfahler, Professor of Roentgenology in the Medico-Chirurgical College of Philadelphia, admitted that his success was only partial, but nevertheless X-ray treatment was more promising than any other method in these post-operative conditions. His procedure was to apply X-rays

as promptly and as vigorously and from as many directions as possible, and to carry the dose to the limit of skin toleration after filtering. The distinctive feature of the method, however, was the combination of X-ray applications with small doses of thyroid extract. Usually he began with the administration of one half-grain of thyroid extract three times a day after meals, increased every four days by one half-grain in the daily dose until the patient was taking 1½ grains three times a day. Dr. Pfahler believed that his results were improved to a considerable extent by the addition of this preparation to the purely X-ray treatment. Dr. N. S. Finzi, speaking on this paper, said that in cases of metastatic carcinoma X-ray treatment not only might be used, but ought to be used, as, except in a few cases, it was the only method available. When, however, there was a solitary small nodule of recurrence, and no evidence of any further disease, he preferred to use the filtered rays of radium.

TUBERCULOSIS

Radiography of the Chest

The Section was particularly happy in its choice of openers in the important discussion on the radiography of the chest on Friday. Both Dr. Hugh Walsham, of London, and Professor K. F. Wenckebach, of Strassburg, combined the parts of radiologist and clinician, and, as a subsequent speaker said, both of them, the one in England and the other in Germany, helped to lay the foundations of scientific chest radiography. Dr. Walsham said that he had made his first chest radiograph as long ago as 1896, and he prophesied then—a prophecy which he had seen no reason to retract—that X-rays would become a very effectual means for the diagnosis of chest disease. Indeed, he would go so far as to say that no chest had been completely examined unless X-rays had been used. His paper took the form of a catechism. What was the value of Williams' sign—that is, the limitation of the excursion of the diaphragm on the affected side in the early cases of pulmonary tuberculosis? He had seen this diminished movement in some early cases, but not in all. What was the value of the deficient illumination of one or other apex as seen by the screen? He was not disposed to place much emphasis upon the value of that appearance. Could X-rays detect pulmonary tubercle before the usual physical methods at the physician's disposal? Personally he thought that they could,

and he quoted an aphorism by his late revered teacher, Dr. Gee, to the effect that in any case of phthisis the disease was more extensive than the physical signs would seem to indicate. Again and again he had found the X-ray picture reveal a disease much more extensive than he had supposed by stethoscopic examination. What was the value of the obliteration of the pleuro-pericardial angle as an early sign of pericarditis with effusion? Occasionally he had found this sign very valuable in the differential diagnosis of this condition and of a subphrenic abscess. With regard to aneurysms of the aorta, was it always possible to diagnose by X-rays between an aneurysm and a mediastinal new growth? He thought that this was an impossibility. To what extent was pulsation of assistance? According to his own observations, not a great deal. Or the shape of the shadow? Again according to his own observations, scarcely at all. Aneurysms and mediastinal new growths might take any shape. On two occasions X-rays had helped him in the diagnosis of cardiac aneurysms, and he found the shape of the heart's shadow useful sometimes in the diagnosis of valvular and congenital disease.

If Dr. Walsham's interesting communication was in the nature of a sketch, Professor Wenckebach's was a filled-in picture. His detailed survey, however, was confined almost entirely to the consideration of the lung shadows. With regard to technique, he laid emphasis upon the great importance of the stereoscopic method in lung examination, and also upon the value of what he called "die Moment-photographie," or the radiography of the chest within the fraction of a second while the breath was held. The instantaneous radiograph obtained by means of specially powerful X-ray apparatus had revolutionized the methods of chest examination, and had brought nearer than before the prompt diagnosis of early tuberculosis. He proceeded to review, first the Roentgen picture of the healthy lung, and then the general pathological changes in the lungs as seen radiogically, the special diagnostic indications for bronchitic affections, for pulmonary inflammations, for tuberculosis, and for pleuritic processes. Two interesting points were specially worthy of record. One was the professor's strong contention that the presence of emphysema did not render a person immune from tuberculosis; and the other his statement that the radiating

lines from the roots of the lung, especially on the right side near the base, were not entirely due to bronchi, some of them being due to vessels. Williams' sign, he believed, was not always present in early tuberculosis, and when present its single evidence was not sufficient to justify a definite diagnosis, but when its presence was established beyond doubt it might generally be taken to indicate a tuberculous invasion.

The discussion for the most part centered around the question of radiographic technique. Dr. Alban Kohler of Wiesbaden and Dr. Fedor Haenisch of Hamburg were of opinion that the intensifying screen was unsuitable for chest radiography, because it blurred the fine detail in the lung structure, upon which everything turned. Dr. Béclère of Paris and Dr. G. Harrison Orton of London dwelt upon the extreme importance of remaining in darkness or semidarkness for some time before attempting to make screen examinations, and the latter also insisted upon the need for a tube of very low penetration and its adjustment so that the suspected side was barely illuminated. The President (Sir James Mackenzie Davidson) urged the use of the stereoscopic method in chest radiography, and Dr. N. S. Finzi was of opinion that underexposure was the most fruitful source of loss of detail. The latter always made his own exposures in the same period of the respiratory cycle—namely, deep inspiration—using the tube as soft as possible, and with as small a diaphragm. By using these methods, he had found that a modern apparatus enabled one to get a chest radiograph sufficiently exposed in about a quarter of a second. Several speakers mentioned the value of precautionary X-ray examination. Dr. Francis Williams of Boston, U. S. A., suggested that this examination should be made in the case of every member of the family of a tuberculous patient. So much impressed was he with the importance of a precautionary examination that about a year ago he suggested to the staff of his hospital that they should ask the trustees to establish a clinic for this purpose. This project had materialized, and the work which had gone forward during the last twelve months made it plain that the universal establishment of such clinics would prove of inestimable value. Another instance of precautionary measures—on this occasion in Paris—was mentioned by Dr. Ledoux-Lebard of that city. During the past eighteen months, he said, he had examined radiologically the chests of all patients who were

about to be operated upon by Dr. Gosset, no matter what the degree of severity of the projected operation. In more than 20 cases, owing to the fact that the screen had shown a doubtful condition of heart or lungs, the operation was abandoned, and in other cases, in which the surgical procedure was absolutely imperative, an unfavourable radiological opinion had proved to be justified by the death of the patient subsequently to the operation.

Several papers on associated subjects were read at the afternoon sitting of the Section. Speaking from the standpoint of the physician, Dr. Sydney A. Owen, of London, passed in review the evidence afforded by a large number of cases as to the early detection of tuberculosis of the lungs by means of X-rays. He expressed the more conservative conclusion that the systematic use of X-rays should be an additional method of physical diagnosis in the early detection of tuberculosis of the lungs where, by the usual methods of examination, it was impossible for the competent physician to arrive at an early, immediate, and definite diagnosis. Another paper, this time on the radiogical diagnosis of thoracic affections in children. was read by two medical men of Nice, Drs. d'Oelsnitz and Paschetta. Systematic radiological exploration of the thorax, they claimed, was most valuable in a series of bronchial and other conditions with which they dealt in turn; sometimes the X-ray picture sufficed for the diagnosis, frequently rectified it, and always made it precise and complete. Speaking on this paper, Dr. J. S. Hirsch, of New York, expressed the view that the radiological examination of chests of infants with meningeal symptoms would frequently disclose evidence differentiating the tuberculosis from other forms of meningitis.

KIDNEY

The technique of Roentgen diagnosis in tuberculosis of the kidney was the subject of a brief note by Dr. Alban Kohler, and the remaining papers dealt with the X-rays from the very different standpoint of a therapeutic agent in tuberculous affections.

RADIOTHERAPY

Drs. Auguste Broca and W. Mahar described the application of radiotherapy to more than 200 cases of localized tuberculosis in the Paris Hospital for Children. The results were favourable, particularly in tuberculosis of the skin, including

lupus. In most of the affections—the tuberculous adenopathies representing the chief exception—the X-ray doses employed were feeble, apparently about one-third of the epilation dose, and the authors considered that strong doses paralyzed the processes of repair. The high percentage of good results was explained on the double ground of a destructive action on the tuberculous cells, and an exciting action on the cells of the neighbouring healthy tissue. Dr. Albert-Weil, of Paris, confirmed this particular X-ray application by instancing some of his own cases, and went on to say that even pulmonary tuberculosis would respond to the employment of X-rays heavily filtered. This last suggestion was more fully dealt with in a paper by Dr. L. Küpferle, of Freiburg, who described some experimental studies in the treatment of pulmonary tuberculosis. The first experiments related to rabbits, and the author said that in these animals tuberculosis could be influenced by means of X-rays, not only at the beginning of its evolution, but at the period of its full development. The effect on applying a hard radiation consisted in the destruction of the tuberculous proliferation tissue. A direct influence upon tubercle bacilli could not as yet be certainly made out by vaccination experiments, but investigations in this direction were proceeding. The irradiation of consumptive people, fifteen in number, had also been undertaken, and it was stated that favourable results were obtained in the first and second phases of the disease (with moderate fever and expectoration) by the application of not too small doses of hard rays. The clinical effects consisted of a slow decrease of temperature, a reduction of cough and expectoration, and an improvement of the general condition.

Dr. Leon Tixier of Mentone described his method of combining heliotherapy and radiotherapy in the treatment of chronic tuberculous adenitis. He had found the sun-baths given on the Riviera a valuable adjunct to X-rays, particularly in the softening form of tuberculous adenitis with a tendency to suppuration. Three months was the time said to be sufficient for the cure.

DEMONSTRATION

The proceedings of the day concluded with a lantern demonstration by Drs. Potocki, Delherm, and Laquerrière illustrating the radiographic images obtained of the fetus. It was stated that, with the aid of intensifying screens, quite visible

silhouettes were forthcoming at the sixth and seventh month, and in some cases at the fifth.

ROENTGEN AND RADIUM THERAPY IN GYNAECOLOGY

The spacious Chemical Theatre of the Imperial College was crowded to overflowing on Monday morning, August 11th, when the Section of Radiology joined forces with that of Gynaecology for a discussion on the question of radio-therapy in gynaecology. The opener was Dr. Albers-Schönberg, who expounded his "Hamburg method" in the application of X-rays, and devoted himself principally to a consideration of their influence upon myomas. The care of his technique, he said, lay in the application of only as much radiation as was necessary to secure the result, irrespective of the long or short duration of treatment. In 33 cases which he instanced as having been brought to a successful issue, the average duration of treatment was between six and seven months. In a noteworthy percentage of cases, he said, there was a direct influence upon the tumour cells, resulting in their depression or disappearance. The proportion of favourable results in this condition was very high—he gave an imposing array of statistics—and the permanency of the cure might be taken for granted in suitable cases. Not all myomas were suitable for Roentgen treatment, some proving refractory. The exact limits of X-ray influence would doubtless in time be determined, but a percentage of cases were reserved for operation. With the advent of careful technique Dr. Albers-Schönberg thought that the danger to the skin might now be practically disregarded, though whether any late reaction was to be apprehended must be left for the future to reveal. The distinguished Hamburg radiologist also touched upon the therapeutic applicability of the characteristic secondary rays of metals. He thought that the effect of these rays could be demonstrated on a biological scale, and also suggested that it was secondary radiation which played an important part in the therapy of mesothorium.

He was followed by Dr. Foveau de Courmelles (Paris), who commended this new gynaecological departure in high terms. Early fibromata, he said, even when of large size, yielded rapidly to X-rays, applied externally through an aluminium filter. Pain and hemorrhage and the sense of weight first

disappeared. The intensity must vary with the radio-sensitivity of the patients, just as the number of sittings must depend upon the duration of the growth. At about the menopause the action was more rapid and decisive, even on an old fibroma. When X-rays failed to maintain their influence, he had found a subsequent radium application—from 1 to 5 cg. around or in the neck of the uterus, retained in position from six to twenty-four hours—retrieve the therapeutic action, at all events if the fibroma were in the earlier stages of its development. Perhaps the most interesting passage of his report was his description of the gynaecological applications of radium. In malign tumours his personal statistics had reference to 100 inoperable cases, 70 of which had shown ameliorations lasting from one to four years. Among other effects which he noted was the diminution and afterwards disappearance of the metrorrhagia, also the disappearance of the leucorrhoea and fetidness, and the diminution, frequently the suppression, of pain. His method was to introduce aseptic tubes within the tumour, the intensity and duration varying with the case, from a minimum of 5 cg. for twenty-four hours, and to repeat the applications monthly.

Professor Paul Kroemer (Greifswald) dealt more especially with the action of mesothorium and X-rays in genital and intestinal cancers. In his total of 32 cases the results in uterine, vaginal, and rectal growth, were favourable; he could not say the same of ovarian. Four cases were illustrated by photomicrographic records before and after treatment. The first of these, a metastasis in the vulva, was cured clinically by the injection of a solution of thorium X. Time would show whether or not the gain were permanent; it could only be said at present that the patients felt better after radio-therapy than after operation. Operation, after all, only cured 20 per cent. of the cases; for the remainder mesothorium and X-rays offered apparently the only hope.

Some remarkable instances of the effect of mesothorium in carcinoma of the uterus also figured in the remarks of Professor Albert Döderlein (Munich). Striking modifications, evident in the microscopical sections, were measurable within a brief period of weeks.

Professor Jacobs (Brussels) said that the results he had obtained by the employment of radium in massive doses in uterine and vaginal cancers, many of the cases being relapses

after operations, led him to the conclusion that this was a most desirable treatment. He used two tubes of radium (12 to 20 cg.), keeping them in the tumour for twenty-four or thirty-six, or even occasionally forty-eight, hours, and repeating these applications every ten or twelve days during four or five weeks. The results were recognized in the course of two or three months. He had submitted to this heroic treatment more than 24 cases of cancer of the uterine neck, and all had been favourably influenced. The cases were not of sufficient duration for him to speak definitely of cure, but in 3, in which he gave detailed accounts, the women being 44, 39, and 70 years of age, the lesions had shown no tendency to recur in from two to three and a half years. For some reason cancer of the external genital organs did not retreat so well under this treatment; perhaps the quantity of radium employed was insufficient.

The chastening note of scepticism was sounded by Professor Wilhelm Nagel (Berlin), who had failed to see results justifying any particular enthusiasm. The tumours had a habit of remaining just as they were. It was true that haemorrhage sometimes stopped, but it returned again after a while. The results described that morning were not better than those which had been obtained by other means. Indeed, Dr. Foveau de Courmelles did not say that he had cured a single case out of his hundreds; he only said that he had not found operation necessary. The prophecy had been made that this new method would supplant the old. He could only repeat a saying which he understood had gained some popularity in this country, "Wait and see."

Dr. Fedor Haenisch was the speaker of the morning to enter most minutely into his technique, giving the exact data for X-ray treatment of fibroids as used now at his institute in Hamburg. He also compared the Hamburg and Freiburg methods, and said that the difference between them, taking into account the recent modifications of the former, was not so great as it seemed if the respective sizes of the point of entrance were considered. His practice was to maintain a distance of 23 cm., a filter of 2 mm. aluminium, a current of 4 to 5 ma., a spark gap of 20 to 24 cm., and to give exposures of five or six minutes, the dose at each sitting being 4 to 5 Kienböck X units, on four consecutive days, followed by a two or three weeks' interval.

Dr. Walter Tate (London) said that radium treatment in this country was still in an experimental stage. No one could doubt the remarkable value of the new therapeutic agents, and he believed that radium had a considerable field as an adjunct to the surgeon. The introduction of a radium tube after operation for uterine carcinoma might improve the result; but it was a different matter to try radium in the treatment of carcinoma when the case was amenable to surgical operation.

Dr. G. E. Pfahler (Philadelphia) made the point that the tumours continued to regress for long after the X-ray treatment was concluded. He instanced a case in which a large tumour was reduced progressively until it had quite vanished at the end of the sixth year, although no radiation had been applied since the end of the first.

Professor Bernhard Krönig, Dr. Degrais, and Dr. Cheron having spoken, the final contribution to the discussion was made by Dr. Herbert Spencer (London), who warned all and sundry against the evident possibility of patients being submitted to radium treatment for myoma without having been examined by an expert gynaecologist. The danger of malpractice appeared to be considerable. Another important point to remember was that irradiation might involve sterility, temporarily at least, if not permanently.

THE VALUE OF RADIOGRAPHY OF BONES AND JOINTS

The Sections of Orthopaedics and Radiology met together on Tuesday, August 12th, to discuss the value of the radiography of bones and joints in orthopaedic surgery.

Dr. G. Nové-Josserand (Lyons) said that radiography rendered possible the study of deformities in the living and during growth. It permitted their recognition, the accurate determination of their morbid anatomy, the distinction of their varieties, the description of their evolution, and the definition of the architectural alteration of bones which resulted from them. It supplied, therefore, information which was valuable both for diagnosis and treatment. It had increased the clinical knowledge of deformities, and had shown the existence of varieties previously unknown and the relations existing between them. Its importance was specially great in the study of congenital scoliosis, of the disease of Dupuytren Madelung,

of congenital dislocation of the hip, of deviations of the neck of the femur, and of flat-foot.

Dr. Paul Redard (Paris) said that radiology, in combination with clinical examination, increased the accuracy of diagnosis and prognosis, and gave to treatment an exactness and precision hitherto unknown. It was, he said, impossible to study a deformity in the living body properly without the aid of radiography. The discovery of Roentgen had been as fruitful for orthopaedics as that of the laryngoscope for laryngology or the ophthalmoscope for diseases of the eye. Much, however, remained to be done, and efforts should be directed to perfecting the technique, which as yet did not always afford results possessing the necessary precision. Stereoscopic radiography was incontestably superior to the ordinary, and it was to this method that special attention should be paid in the future.

Dr. Fedor Haenisch (Hamburg) insisted upon the importance of the study of the normal osteology, as shown by the Roentgen rays. All the abnormalities of bones likely to be found must be known so as to avoid mistaking them for the results of trauma or of disease. In speaking of epiphysial lesions, he said that some cases of supposed birth palsy were really cases of displaced upper epiphysis of the humerus, with rotation of the rest of the bone. These were curable by operation on the bone. He spoke of the importance of radiography in fractures and in scoliosis, referred to Max Böhm's researches on this subject, and to its value also in controlling treatment. The early diagnosis of spondylitis in Pott's disease was of the very greatest importance, and was best attained by the X-rays; the presence of abscess was readily discovered by this means. Lesions of the pelvis or parts of it, hip disease, and congenital dislocation of the hip, could all be diagnosed and their treatment controlled by the help of X-rays, as also coxa vara, and injuries of the head and neck of the femur. He referred to Preiser's work on abnormal situations of the acetabulum, and its influence on the production of arthritis deformans; to Schlatter's disease of the tubercle of the tibia; to abnormalities and injuries of the bones of the feet, such as spurs of the os calcis; to abnormal number of ossification centres in the cuneiform bones; to tuberculosis of the foot and fracture of the metatarsal bones; myositis ossificans and bone tumours were also to be mentioned.

Dr. Paul-Vital Badin (Paris) read a communication on the importance of radiography in the study of flat-foot in adolescents. He explained by diagrams that in the normal foot the relative position of the tarsal bones was little different in the unloaded foot and in that bearing the weight of the body, while in flat-foot the position changed very much.

Dr. Finzi (London) showed photographs and radiographs illustrating Madelung's deformity of the wrist, which is characterized by a subluxation of the carpus forwards, causing undue prominence of the lower end of the radius. These radiographs showed that the deformity in these particular cases was not due to bowing of the shaft of the radius but to irregular ossification at the lower epiphysis with turning inwards of the articular surface of the radius.

Professor Froelich (Nancy), who followed, showed on the other hand radiographs of cases in which a general curvature of the shaft of the radius, convex dorsally, was the cause of the deformity. There is probably no one pathological entity responsible for the symptoms of Madelung's deformity, which may have various causes.

Mr. R. C. Elmslie showed radiographs of cases of supposed hip disease in which the symptoms were really due to irregular and imperfect ossification of the upper end of the femur. These cases were supposed to be cured by treatment for hip disease.

Dr. Mauclaire showed radiographs of coxa valga, etc.

PRELIMINARY REPORT OF COMMITTEE ON NOMENCLATURE.

The following nomenclature is suggested by the Committee on Nomenclature for adoption by the Society:

Roentgenography	The specialty in medicine which makes use of the Roentgen ray.
Roentgenology	The study of the Roentgen ray.
Roentgenologist	A physicist learned in the physics of the Roentgen ray but not necessarily a worker with it.
Roentgenographer	Specialist in the use of the Roentgen ray.
Roentgenograph	Apparatus used.
Roentgenogram	The photographic product.
Roentgenoscopy	To view with the Roentgen ray.
Roentgen-fluoroscopy	Fluoroscopic examination with Roentgen ray as source of light.
Roentgen-diagnosis	Diagnosis by means of Roentgen ray.
Roentgen-therapy	Treatment by means of Roentgn ray.
Roentgen-irradiation	Exposure to the Roentgen ray.
Roentgenism	To suffer from the effects of the Roentgen ray.
Roentgenization	To use Roentgen rays in diagnosis and treatment.

(Signed) FRED C. ZAPFFE, Chairman.
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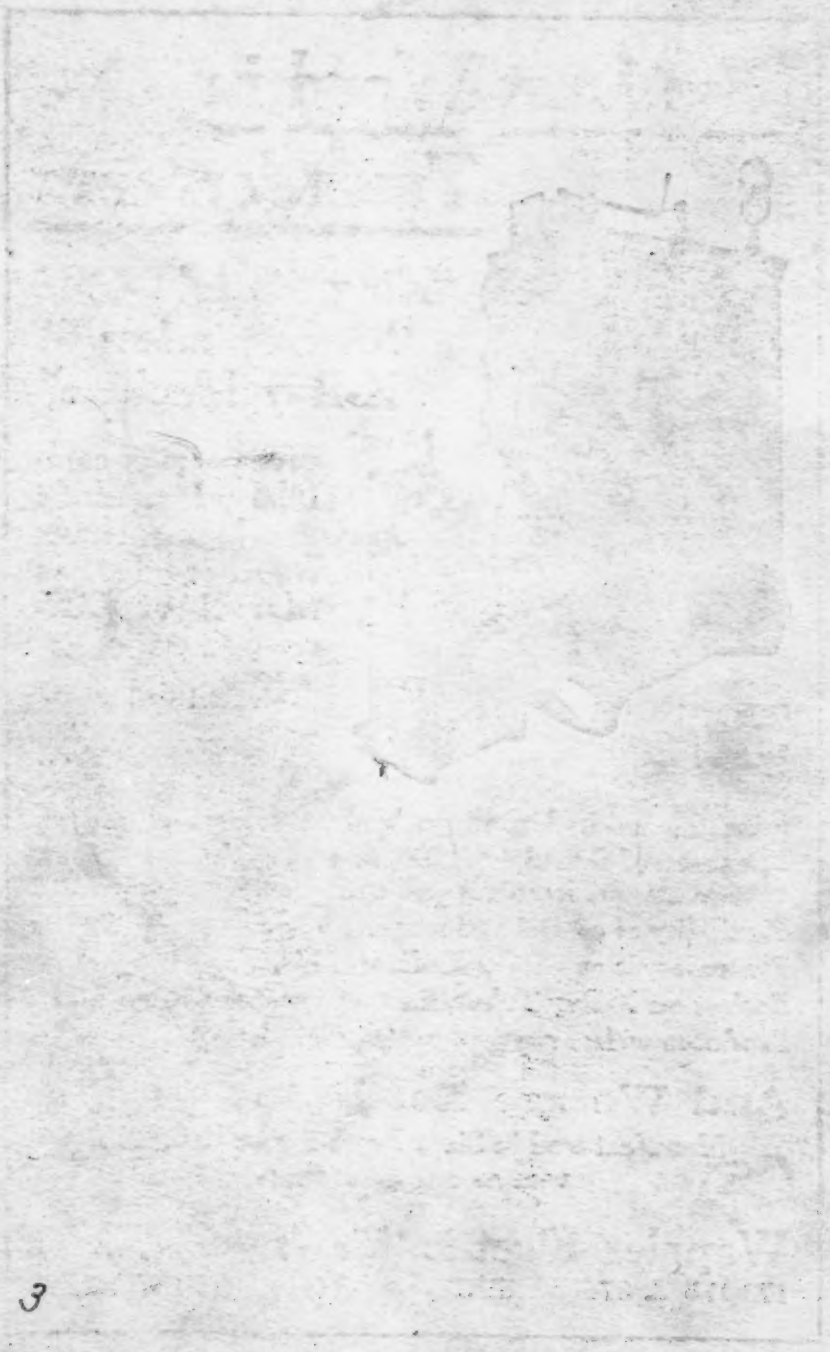

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